IV.1 Suspended particulate matter

Air pollution from suspended particulate matter of PM_{10} and $PM_{2.5}$ fractions remains one of the main problems to be resolved in ensuring air quality in the CR. Exceeding pollution limit levels for PM_{10} and $PM_{2.5}$ continues to contribute to the extent of areas with above-limit air pollution.

IV.1.1 Air pollution by suspended particulates in 2021

Suspended PM_{10} particulate matter

The 24-hour pollution limit level for PM_{10} (the average 24-hour concentration of 50 $\mu g \cdot m^{-3}$ is possible to exceed 35 times a year) was exceeded in 2021 at less than 3 % of stations (4 stations of a total number of 152 with a sufficient amount of data for evaluation; Fig. IV.1.1, and Fig. IV.1.2). This concerned two industrial stations – Ostrava-Radvanice-ZÚ (57 cases exceeding the limit) and Karviná (51 cases), the rural station Věřňovice (56 cases), and the urban background station Rychvald (42 cases). All stations exceeding the emission limit are located on the territory of the O/K/F-M[1] agglomeration.

The Ostrava-Radvanice-ZÚ, Věřňovice, Karviná and Rychvald stations, similarly to other stations in the O/K/F-M agglomeration, are long-term affected by long-range transport of pollution from Poland. The Ostrava-Radvanice-ZÚ station is also affected by industrial emissions and Karviná by emissions from construction activities. At the Věřňovice station, there is a combination of the impact of air pollution from southern Poland and rural development on the Czech side of the border, together with specific meteorological conditions in the Olše River valley. The representativeness of the Věřňovice station for the Czech countryside is therefore limited and the measurement results from this station are not included in other statistical characteristics (annual trend of monthly concentrations and concentration trends).

The pollution limit level for the average 24-hour concentration of PM_{10} was exceeded in 2021 in only 0.1 % of the territory of the CR, with approx. 0.4 % of the population (Fig. IV.1.3). Compared to previous years (0.001 % of the territory in 2020, 0.3 % in

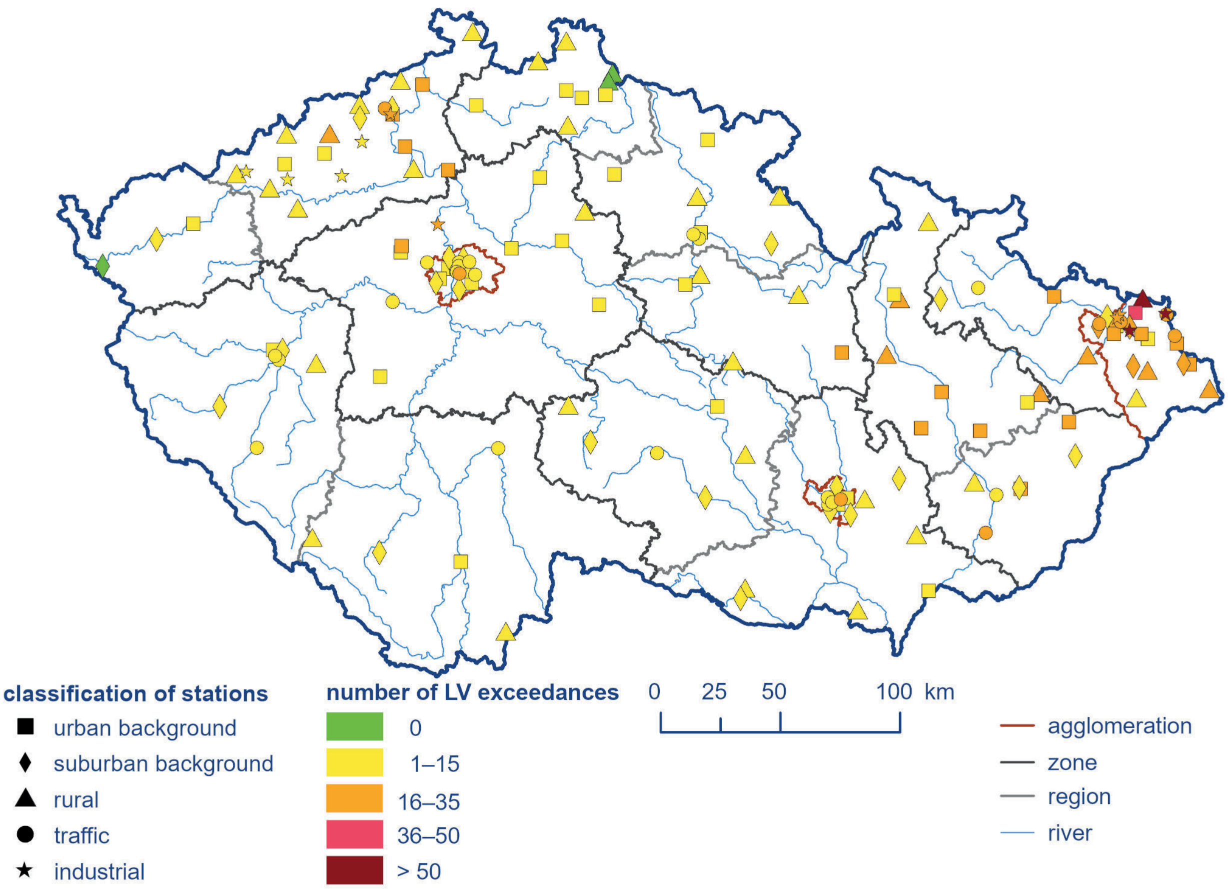

Fig. IV.1.1 Number of cases exceeding the pollution limit value of 24-hour average PM_{10} concentrations at air quality monitoring stations, 2021

1 At the Brno-Zvonařka industrial station, which is significantly affected by construction activities, the value of the 24-hour pollution limit was exceeded 36 times in 2021. However, the station did not have sufficient data for evaluation according to Annex 1 to Decree No. 330/2012 Coll., and thus cannot be included in the overall statistics.

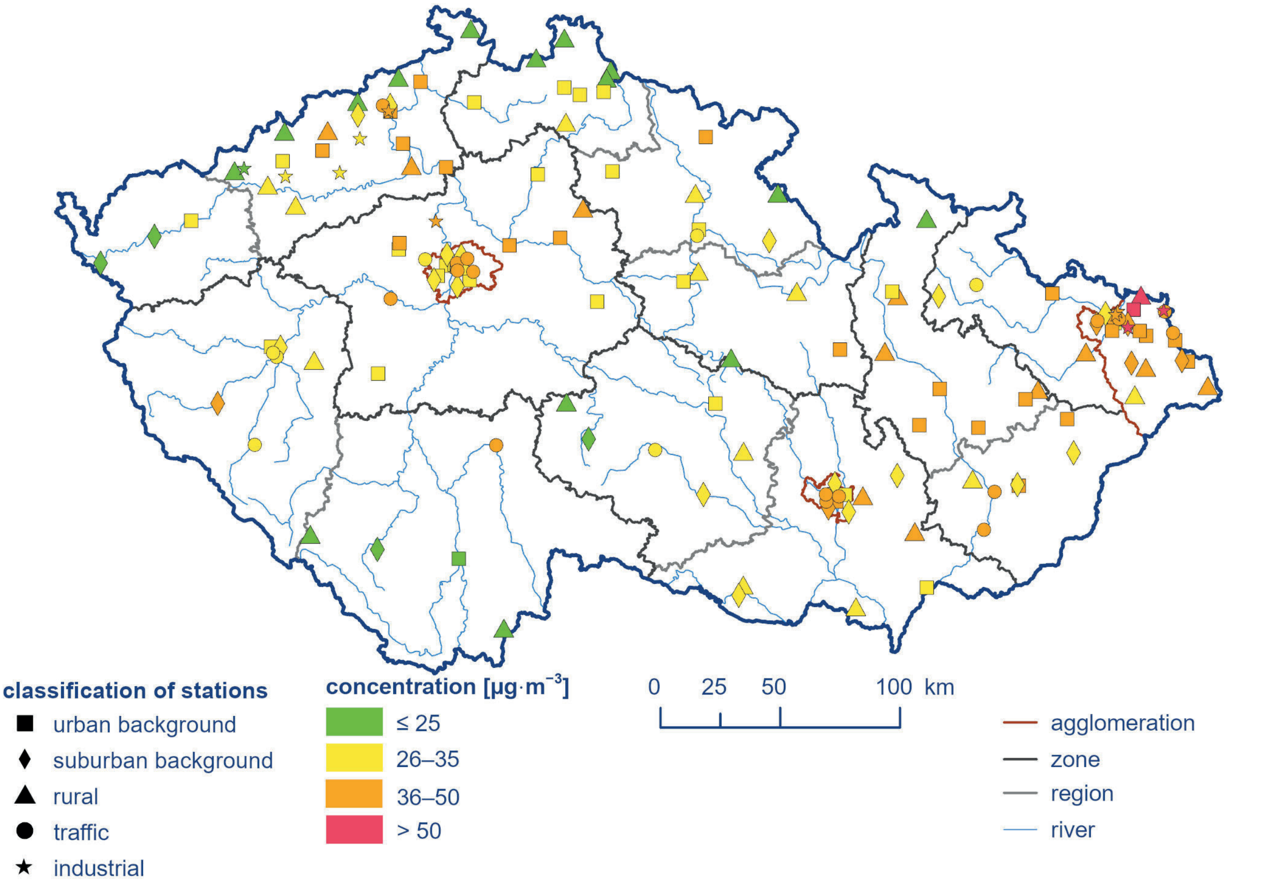

Fig. IV.1.2 The 36th highest 24-hour PM_{10} concentrations at air quality monitoring stations, 2021

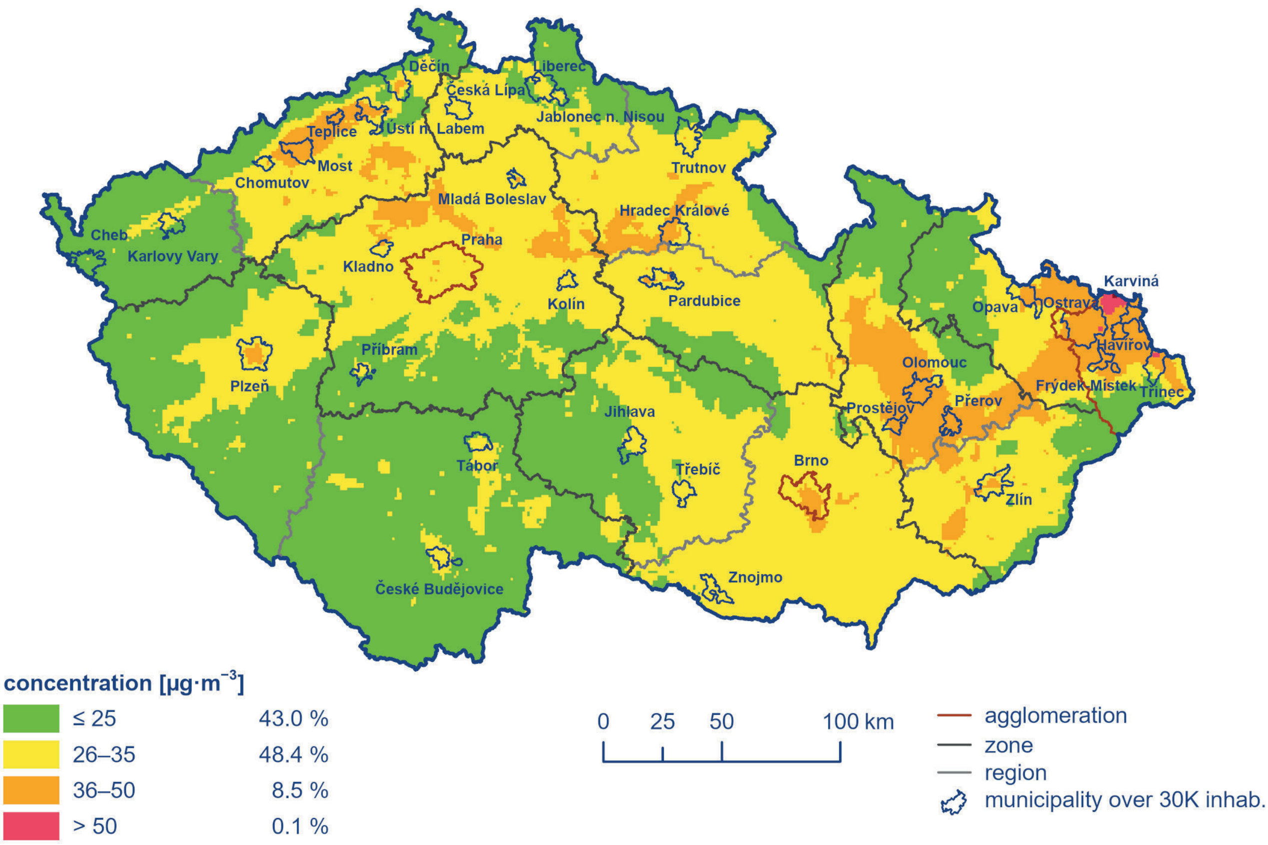

Fig. IV.1.3 Field of the 36th highest 24-hour PM_{10} concentration, 2021

Fig. IV.1.4 The 36th highest 24-hour and annual average PM_{10} concentrations at selected stations of UB, SUB, I, and T classification, 2011–2021

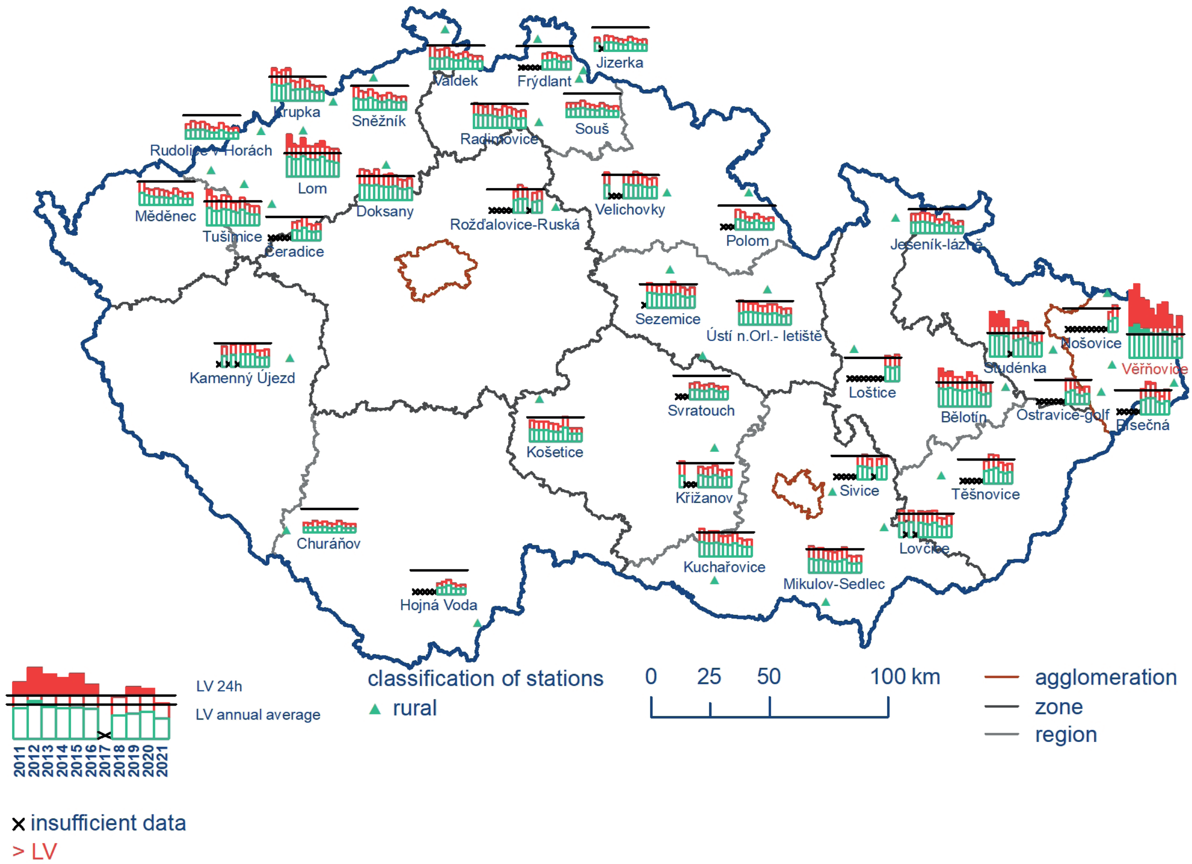

Fig. IV.1.5 The 36th highest 24-hour and annual average PM_{10} concentrations at selected rural (R) stations, 2011–2021

2019, 3.2 % in 2018, and 8.3 % in 2017), the year 2021 ranks among the years with a smaller area of the CR exposed to above-limit concentration of PM_{10}, which corresponds to a low number of cases exceeding the pollution limit at measuring stations. A large part of the territory of the CR (87 %) was exposed to a concentration up to 35 μg·m^{-3} in 2021, that is to concentrations below the upper assessment limit set by Decree No. 330/2012 Coll., on the method of assessment and evaluation of ambient air pollution levels and on the extent of informing the public on the level of ambient air pollution and during smog situations[2].

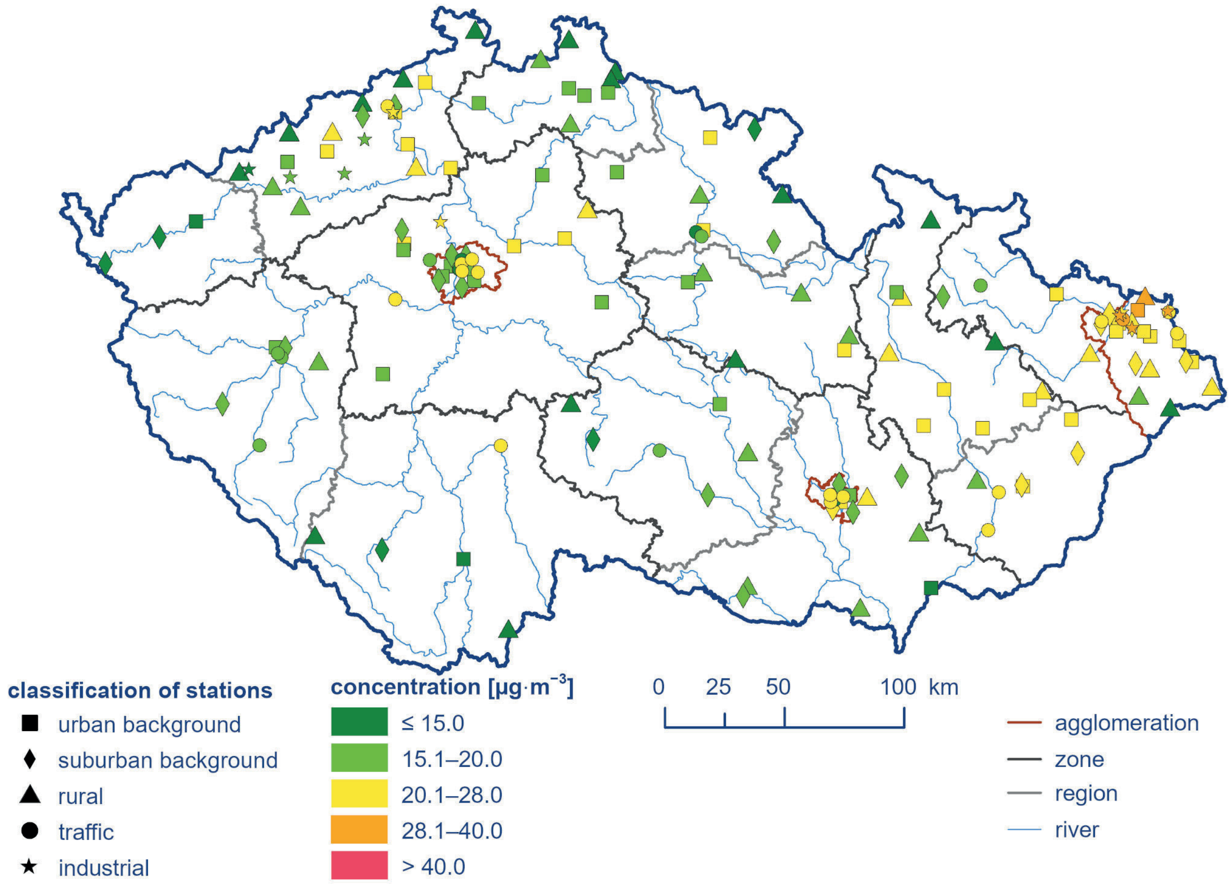

Fig. IV.1.6 Annual average PM_{10} concentrations at air quality monitoring stations, 2021

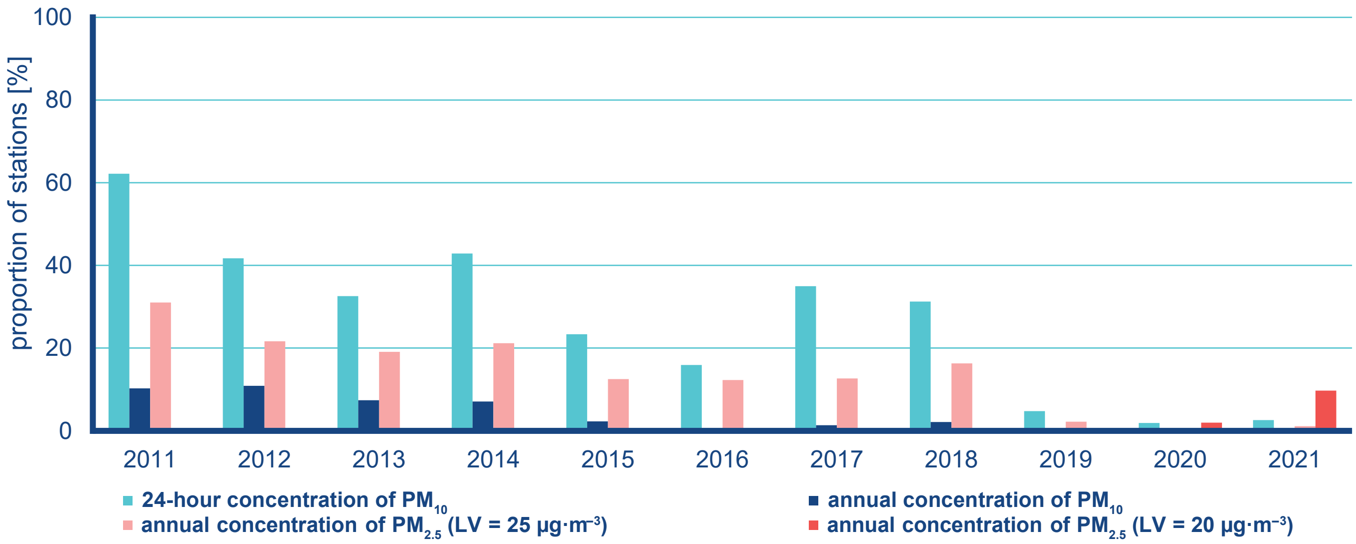

Fig. IV.1.7 Ratio of stations where the pollution limit level of 24-hour average PM_{10} concentration and of annual average PM_{10} and $PM_{2.5}$ concentration was exceeded, 2011–2021

2 The upper and lower assessment thresholds for assessing the level of pollution and the permitted number of cases exceeding the limit are set out in Annex 4 to this Decree. For more, see the introduction to Ch. IV.

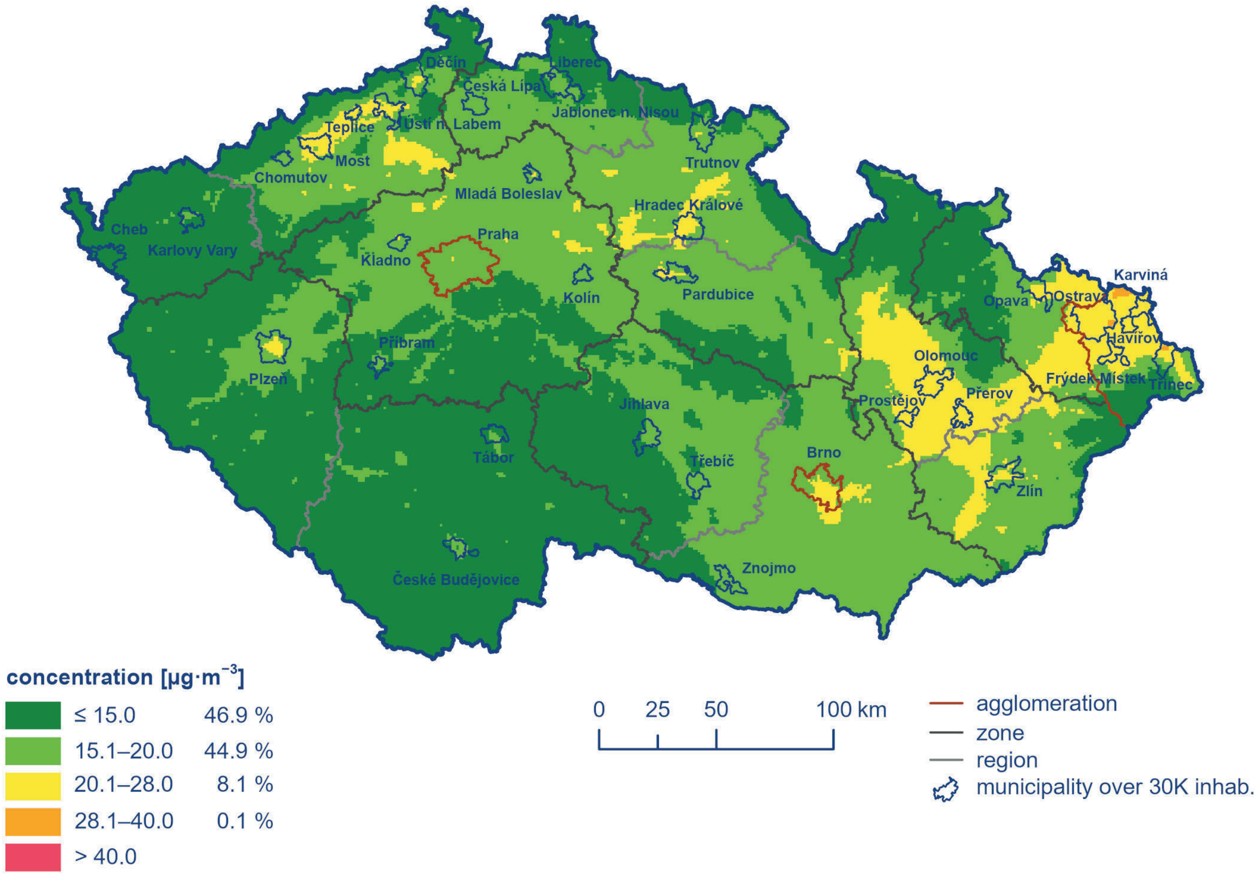

Fig. IV.1.8 Field of annual average PM_{10} concentration, 2021

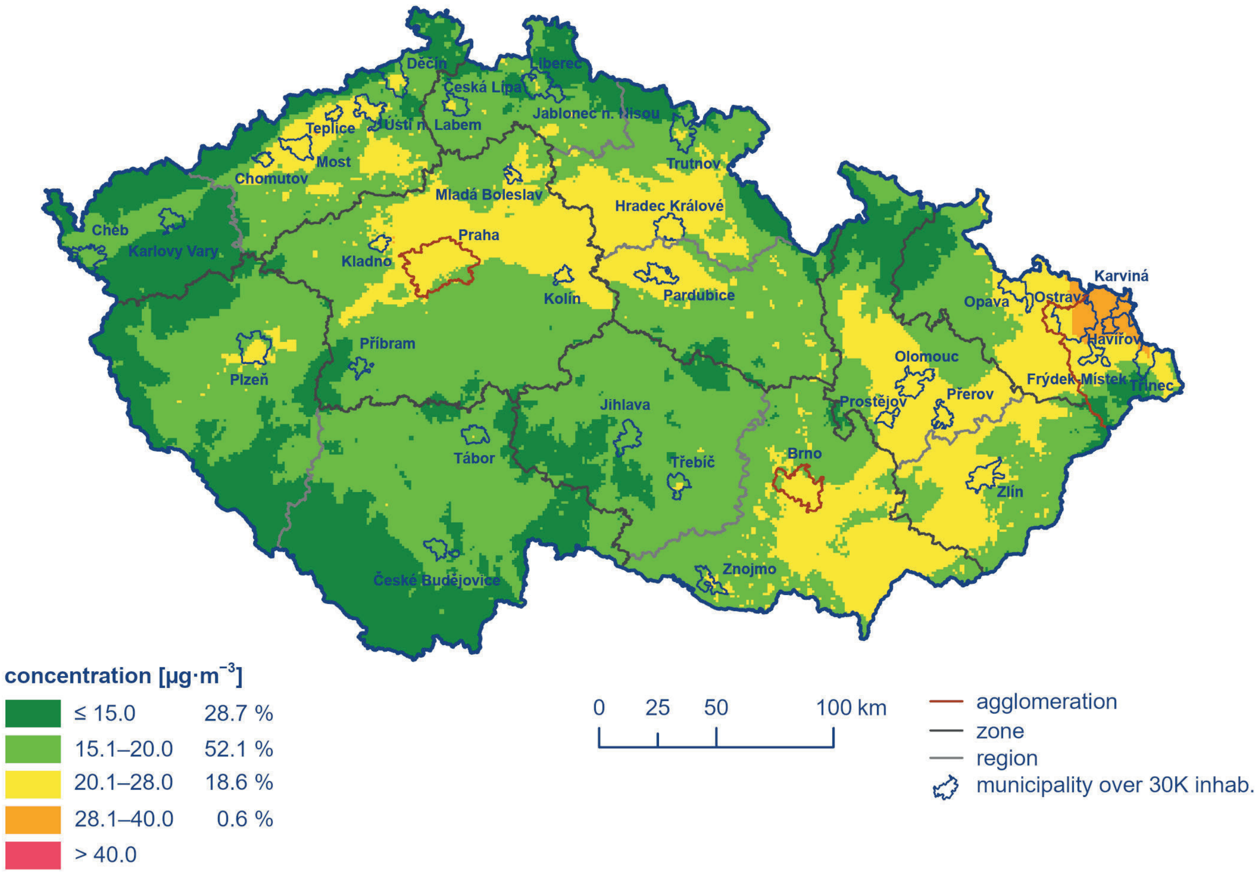

Fig. IV.1.9 Five-year average of annual average PM_{10} concentrations, 2017–2021

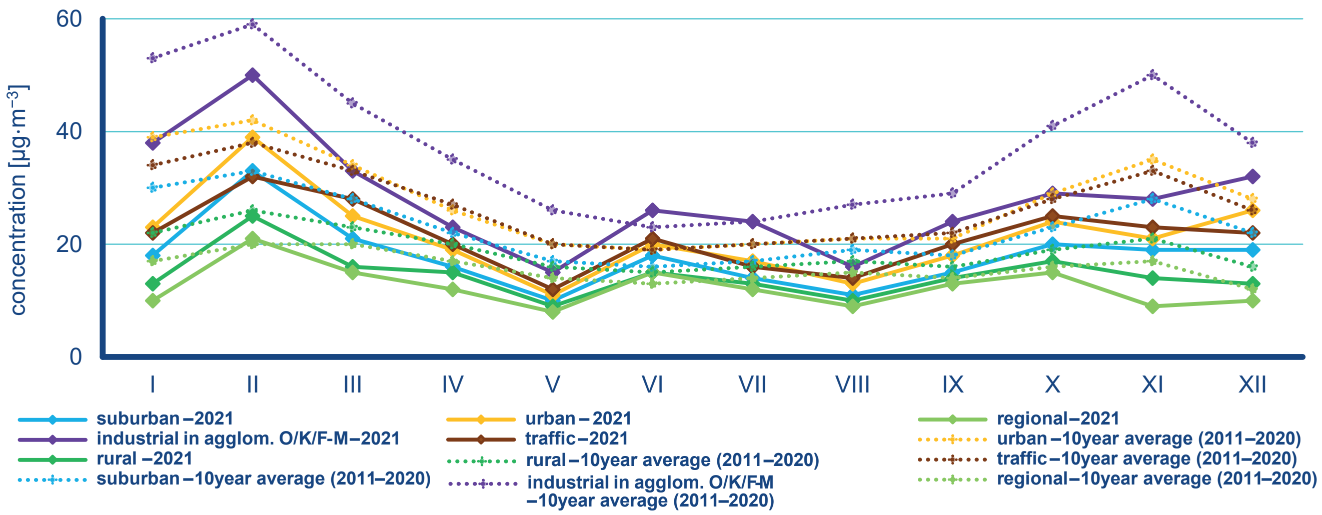

Fig. IV.1.10 Annual course of average monthly PM_{10} concentrations (averages for a given type of station), 2021

As in previous years, the O/K/F-M agglomeration was the most polluted continuous area (Fig. IV.1.4 and IV.1.5).

The pollution limit for the average annual concentration of PM_{10} (40 µg·m^{-3}) was not exceeded at any station in the CR in 2021, which occurred, together with 2019 and 2020, for the third time for the entire history of PM_{10} observation since 1993. The highest annual average concentrations were measured at stations of the O/K/F-M agglomeration (Fig. IV.1.6). Similar to previous years, the highest annual average concentrations were measured at the Ostrava-Radvanice ZÚ industrial station (34.3 µg·m^{-3}), at the Věřňovice rural station (32.4 µg·m^{-3}), and at the Karviná industrial station (31.5 µg·m^{-3}).

Similar to 2019 and 2020, no territory of the CR had an above-limit annual average concentration of PM_{10} at a spatial resolution of 1×1 km (Fig. IV.1.8). However, in previous years the annual average concentration of PM_{10} was exceeded on only small part of the territory of the CR (0.1 % in 2018, and 0.02 % in 2017). In terms of the five-year average of annual average concentrations, the most polluted area is the O/K/F-M agglomeration (Fig. IV.1.9).

PM_{10} concentrations exhibit a clear annual variation, with the highest values in the cold months of the year (Fig. IV.1.10), when the 24-hour pollution limit is most often exceeded (more than 85 % of cases exceeding the limit occur in January, March, and December). Higher air PM_{10} concentrations during the colder season relate both to greater emissions of particulates from seasonally operated heating sources and also to more frequent occurrence of poorer dispersion conditions this part of the year.

The annual variation of PM_{10} concentrations in 2021 had a less distinct trend compared to the ten-year average showing a clearer dominance of autumn and winter months. In 2021, the highest PM_{10} concentrations were measured in February, when moderately poor to poor dispersion conditions occurred. In February, increased concentrations of PM_{10} were observed on several days throughout the CR, also in connection with the transfer of sand particles from the Sahara. In the remaining months of the cold season of the year, i.e., in January, March and in the last three months of the year, the concentrations were at a similar level (Fig. IV.1.10).

Average monthly PM_{10} concentrations in 2021 compared to the ten-year average (2011–2020) were lower in all months of the year, except for June. The decrease in PM_{10} concentrations at stations was especially significant in January (a decrease by almost 13 µg·m^{-3}, i.e., by 40 %) and in November (a decrease by almost 11 µg·m^{-3}, i.e., by 36 %). At the beginning of 2021 (January–March), standard dispersion conditions prevailed, with the exception of February (deteriorated dispersion conditions), the months were characterized as normal in terms of temperature and normal to subnormal in terms of precipitation. The conditions determining fuel consumption (emission intensity), self-cleaning of the atmosphere and dispersion of pollutants in January-March 2021 were therefore mostly average to slightly below the average. Nevertheless, the average monthly concentrations of suspended particles decreased compared to the ten-year average 2011–2020, although due to conditions mentioned above, it would be possible to assume their increase to the levels or above the levels of the average ten-year concentrations. This decrease in concentrations points to decreasing emissions of suspended particles due to the gradual modernization of emission sources (large sources following the application of BAT, exchange of boilers heating households with solid fuels, renewal of the vehicle fleet). Lower average monthly concentrations of PM_{10}, compared to the ten-year average 2011–2020, were also observed in April, which was subnormal in terms of temperature and precipitation, when a partial impact of emissions from local heating can still be assumed.

The end of the year (October–December) was normal in terms of temperature and precipitation, with only October assessed as below normal in terms of precipitation. Dispersion conditions, compared to the ten-year average 2011–2020, were characterized as standard, however, adverse conditions with low frequency occurred in January compared to ten-year period, while adverse conditions did not occur in October neither in November 2021 (Fig. III.3 and III .4). Relatively good dispersion conditions also

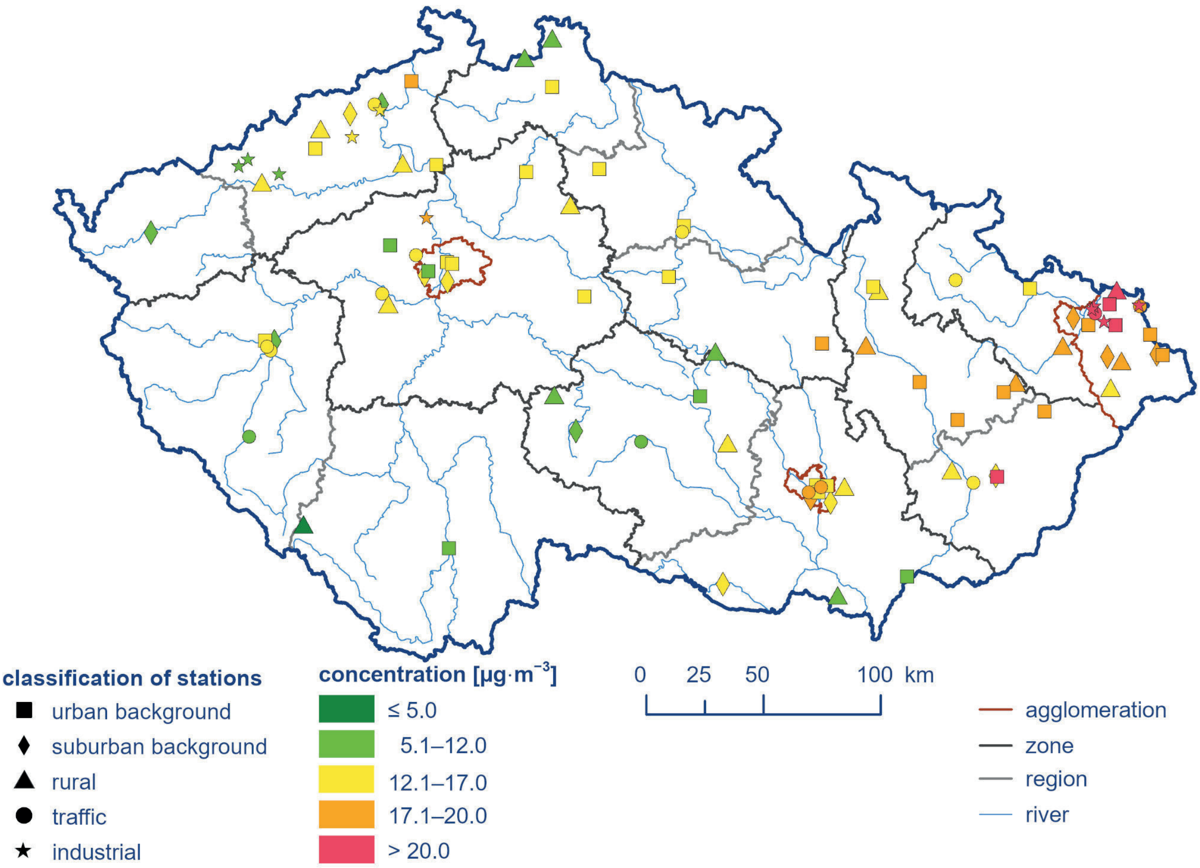

Fig. IV.1.11 Annual average $PM_{2.5}$ concentrations at air quality monitoring stations, 2021

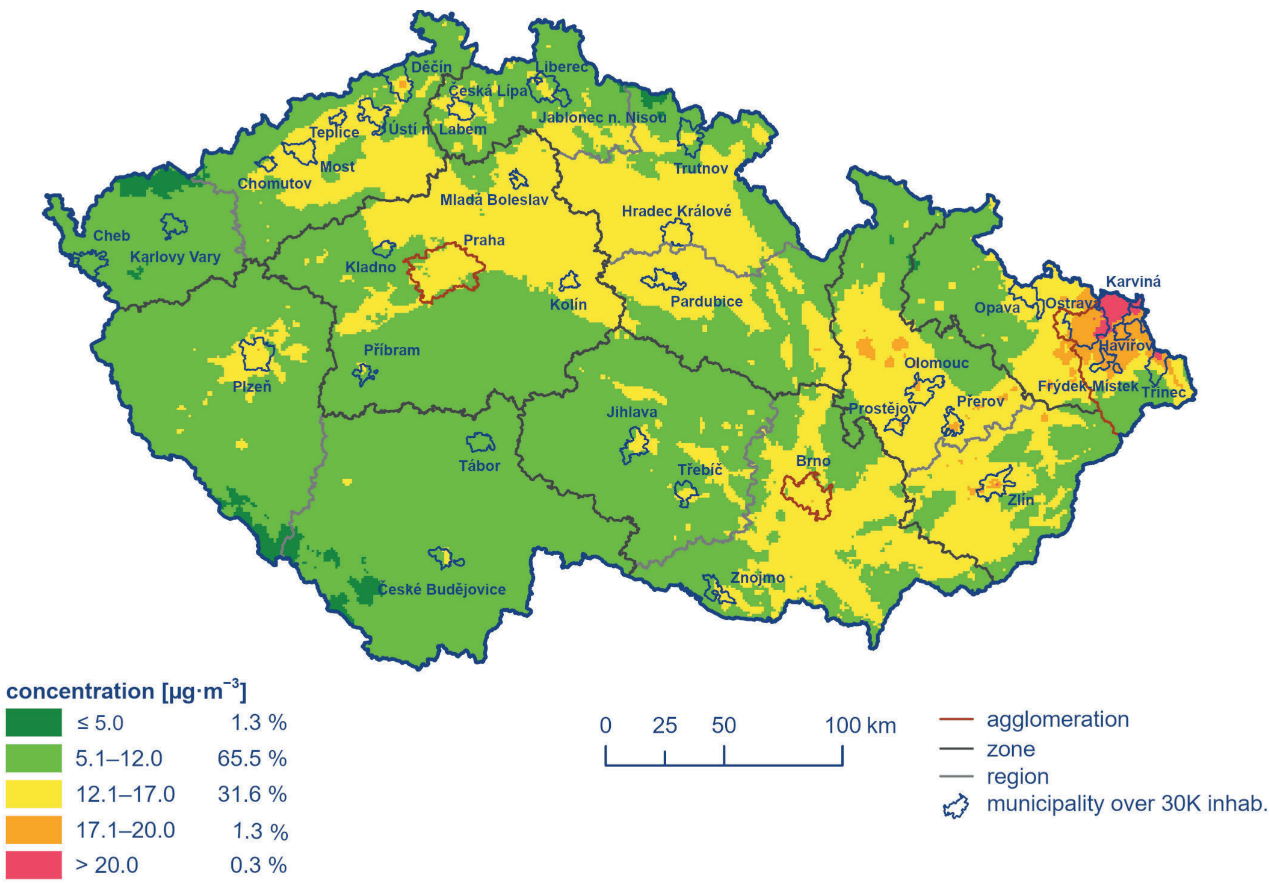

Fig. IV.1.12 Field of annual average $PM_{2.5}$ concentration, 2021

Fig. IV.1.13 Annual average $PM_{2.5}$ concentrations at selected stations, 2011–2021

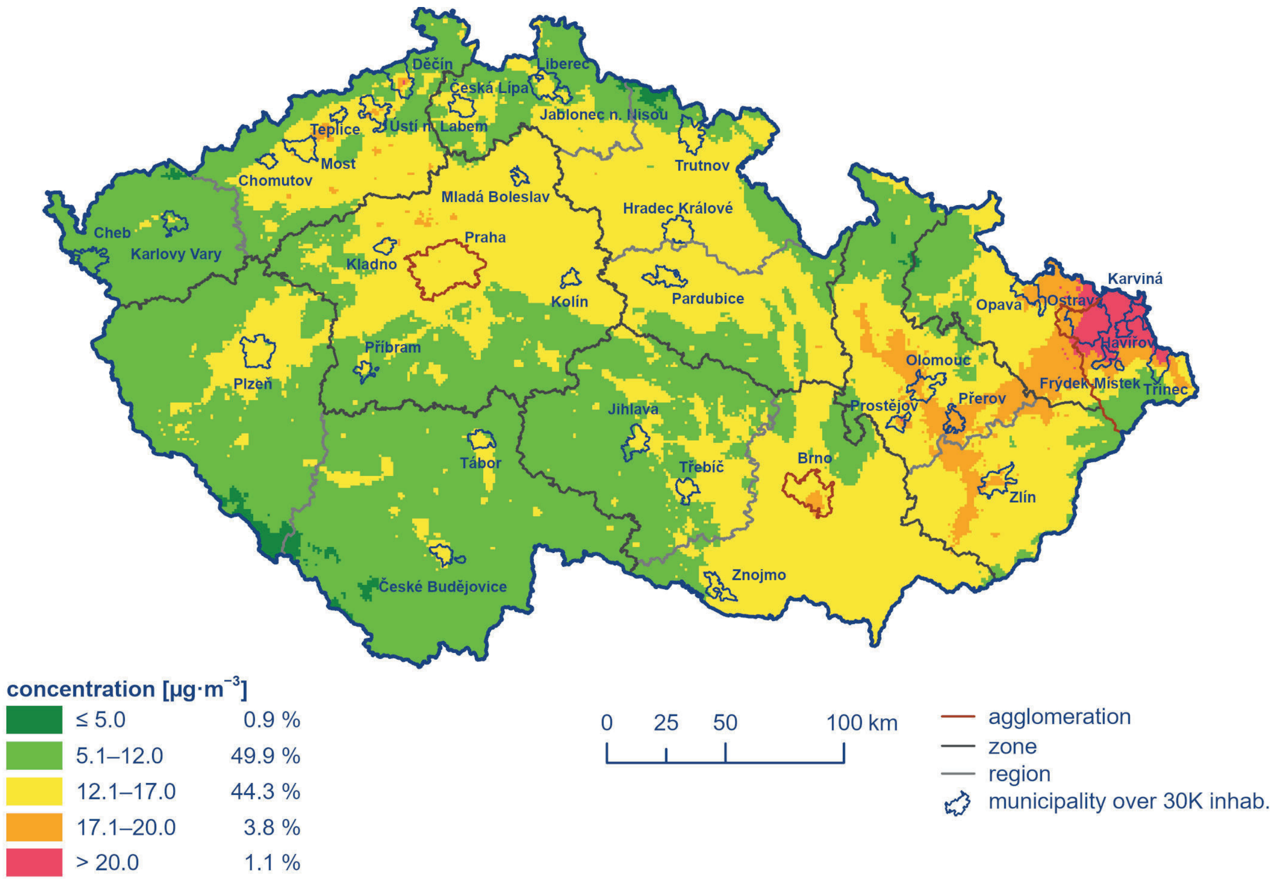

Fig. IV.1.14 Five-year average of annual average $PM_{2.5}$ concentrations, 2017–2021

contributed to the decrease in monthly concentrations in these months. In December, poor dispersion conditions occurred and PM_{10} concentrations increased above the pollution limit value, as a result of which a smog situation was announced for the territory of the O/K/F-M agglomeration without Třinec between 27 and 29 December 2021 (see Chapter VI).

Concentrations at a lower level are typical for the summer period of the year (April–September), when seasonal sources attenuate. Concentrations are strongly affected by the occurrence of drought, which leads to dustiness and a subsequent increase in the concentration of suspended particles in the air. The lowest average monthly concentration in 2021 was measured in May and August. In addition, significantly good dispersal conditions prevailed in May. On the contrary, the increase in concentrations in June was probably related to the low amount of precipitation in the first two thirds of the month and the strongly above-normal temperature.

In 2021, similarly to 2020, states of emergency were declared on the territory of the CR in connection with the occurrence of the SARS-CoV-2 coronavirus. From the point of view of the potential change in air quality in the CR, the most significant month was March, when even movement between districts was prohibited. Due to the heterogeneous composition of PM_{10} emission sources and their strong relationship with dispersion and meteorological conditions, no significant changes in concentrations can be expected as a result of emergency measures. On the one hand, there was a decrease in emissions of suspended particles and nitrogen oxides (precursors of secondary suspended particles) from transport, on the other hand, the likely higher intensity of heating due to the population remaining in the home environment led to higher emissions of particles from local heating (CHMI 2020). A more detailed evaluation of the effect of the state of emergency to the change in air quality in the CR can be referred to in CHMI (2021).

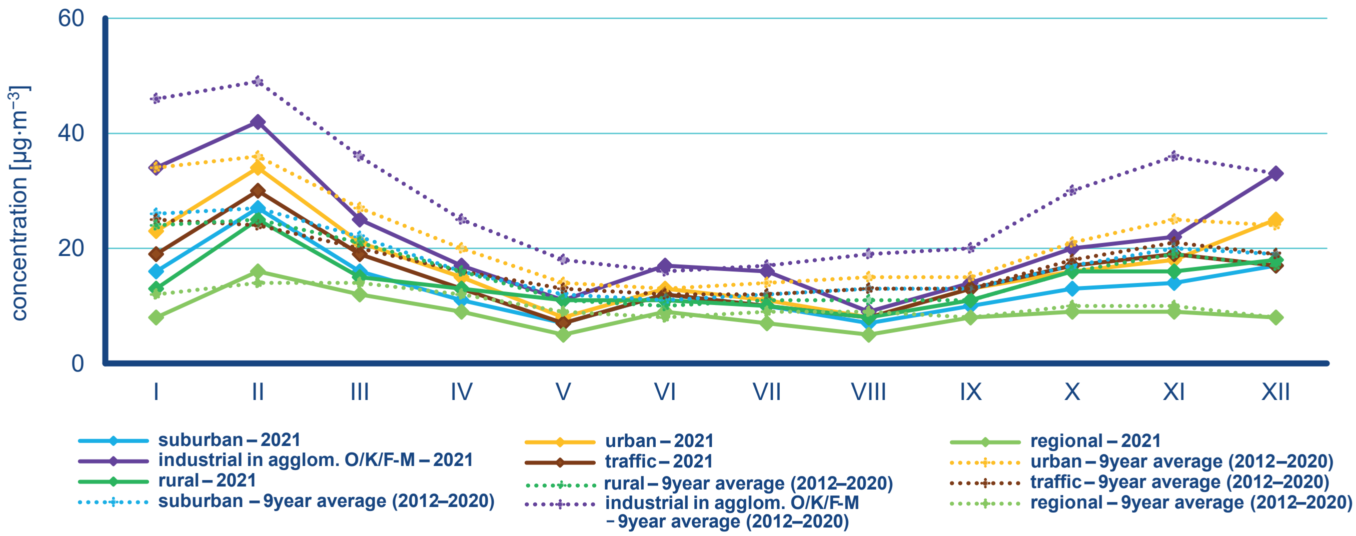

Fig. IV.1.15 Annual course of average monthly $PM_{2.5}$ concentrations (averages for a given type of station), 2021

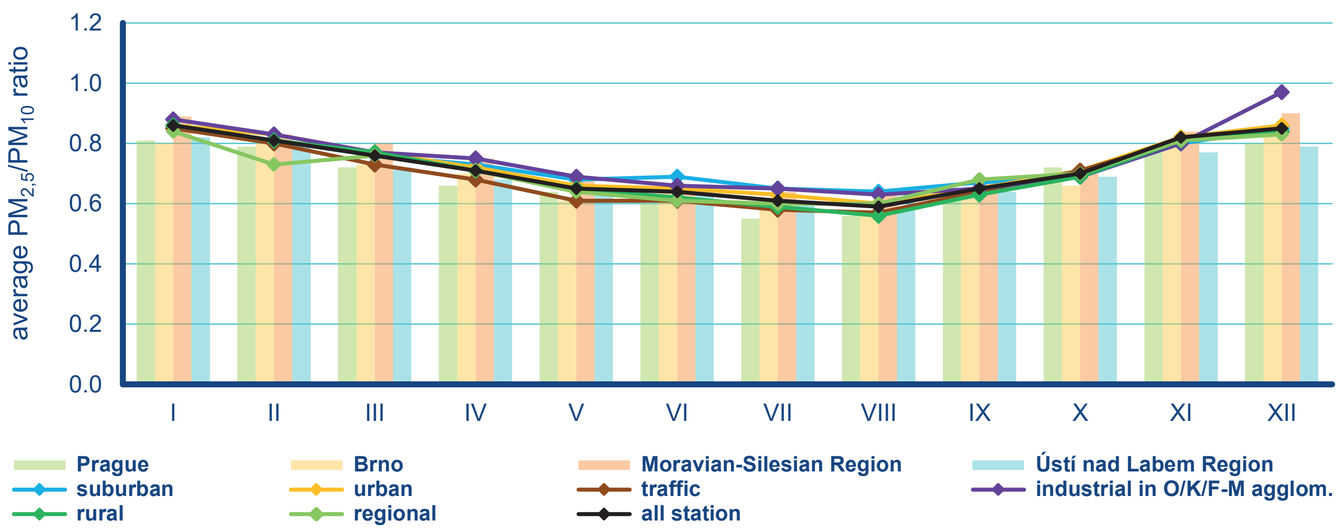

Fig. IV.1.16 Monthly average ratios of $PM_{2.5}/PM_{10}$, 2021

Suspended $PM_{2.5}$ particulate matter

In 2021, the pollution limit level for the average annual concentration of $PM_{2.5}$ (20 μg·m^{-3})[3] was exceeded at 9 stations (9.7 %) of a total of 93 stations. All stations where the average annual concentration of $PM_{2.5}$ was exceeded in 2021 (except for the Zlín-ZŠ Kvítkova city background station) were located in the territory of the O/K/F-M agglomeration (Fig. IV.1.11). For comparison with previous years, it can be stated that in terms of the limit value valid until 2019 (25 μg·m^{-3}), the limit was exceeded in 2021 at the Ostrava-Radvanice ZÚ station only, where the annual average concentration of 23.3 μg·m^{-3} was measured. The second highest concentration was measured at the Věřňovice station (24.3 μg·m^{-3}).

The pollution limit level for the average annual concentration of $PM_{2.5}$ was exceeded in 2021 over 0.3 % of the territory of the CR with approx. 1.5 % of the population (Fig. IV.1.12). In 2020, this concerned 0.04 % of the CR territory with approx. 0.2 % of the population.

In the evaluated period 2011–2021, above-limit annual average concentrations of $PM_{2.5}$ were observed mainly on the territory of the O/K/F-M agglomeration (Fig. IV.1.13). In terms of the five-year average of annual average concentrations of $PM_{2.5}$, the most polluted area is the O/K/F-M agglomeration (Fig. IV.1.14).

Monthly $PM_{2.5}$ concentrations show annual variation very similar to that of PM_{10}, including a significant decrease in average monthly concentrations compared to their ten-year average. The highest concentrations were measured in February. Average monthly $PM_{2.5}$ concentrations in 2021 compared to the ten-year average (2011–2020) were lower, except for June, in all other months of the year. The decrease in PM_{10} concentrations at the stations was especially significant in January (decrease by 10 μg·m^{-3}, i.e., by 38 %), March (decrease by 6 μg·m^{-3}, i.e., by 25 %), August (decrease by 6 μg·m^{-3}, i.e., by 45 %), and in November (decrease by almost 5 μg·m^{-3}, i.e., by 27 %).

Ratio of the $PM_{2.5}$ and PM_{10} suspended particle fractions

The ratio of the $PM_{2.5}$ and PM_{10} fractions is not constant but exhibits seasonal variations and is also dependent on the character of the location (Fig. IV.1.16). In 2021, an average value of 68 stations in the CR where $PM_{2.5}$ and PM_{10} are measured simultaneously and have a sufficient number of measurements for evaluation ranged from 0.59 (July) to 0.86 (January). In Prague and Brno, where annual variations are affected by the high proportion of traffic locations, this ratio ranged from 0.55 (July) to 0.81 (February), and from 0.58 (August) to 0.82 (December), respectively. In the Moravian-Silesia region, the ratio ranged from 0.63 (August) to 0.90 (December) and in the Ústí nad Labem region from 0.59 (August) to 0.82 (January). When the ratio of $PM_{2.5}$ and PM_{10} fractions is compared by location type, the ratio at rural locations ranges from 0.56 (August) to 0.86 (January), at urban backgrounds from 0.60 (August) to 0.86 (January, December), at suburban backgrounds from 0.64 (August) to 0.85 (January, December), at traffic locations from 0.57 (August) to 0.85 (January), and at industrial locations from 0.63 (August) to 0.97 (December).

The annual variation in the ratio of the $PM_{2.5}$ and PM_{10} fractions is related to a seasonal character of certain emission sources. Emissions from combustion sources exhibit a greater content of the $PM_{2.5}$ fraction than, e.g., emissions from agricultural activities and resuspension during dry and windy weather. Heating in winter can thus lead to a greater content of the $PM_{2.5}$ fraction compared to the PM_{10} fraction. The highest $PM_{2.5}/PM_{10}$ ratio in 2021 was identified in February, regardless of the location type. The occurrence of highly above-normal amount of precipitation in February had a role in this aspect (Chapter III). $PM_{2.5}/PM_{10}$ ratios are generally higher in wet months due to a smaller contribution of resuspension to PM_{10} concentration (Akinlade et al. 2015). Decreases during the spring and beginning of the summer have also been explained by some studies as being a result of the amount of larger biogenic particulates, e.g. pollen (Gehrig, Buchmann 2003).

The $PM_{2.5}$ to PM_{10} ratio is the lowest at traffic locations. When fuel is combusted in traffic, the particulates are mainly in the $PM_{2.5}$ fraction and the ratio should therefore be higher at traffic locations. The fact that this is not the case emphasises the importance of emissions of the largest particulates swirling from the road surface, as well as emissions from the abrasion of tyres, brake linings and roads. The proportion of the larger fraction at traffic stations is also increased as a consequence of resuspension of particulates from the application of grit to roads during winter. Increases in PM_{10} concentrations can also occur as a result of greater road surface abrasion by this grit and the subsequent resuspension of abraded material (EC 2011). On the contrary, a higher ratio of $PM_{2.5}$ to PM_{10} fractions resulting from emissions from combustion processes is observed at industrial stations.

IV.1.2 Trends in the concentrations of suspended PM_{10} and $PM_{2.5}$ particulates

The trend in concentrations of suspended PM_{10} particles at particular types of stations is evaluated for the last 11 years, i.e. 2011–2021.

36th highest 24-hour PM_{10} concentration (on average from all stations with measurements available for the entire evaluated period) ranged from about 32 to 58 μg·m^{-3} in the period 2011–2021 (Fig. IV.1.17). Minimum concentrations during the evaluated period were recorded in 2020, the maximum in 2011. 36th highest 24-hour PM_{10} concentrations decreased gradually in 2011–2016, an increase was observed in 2017 and 2018, and a gradual decre-

3 In 2020, in connection with EU legislation, a stricter limit value of 20 μg·m^{-3} for the annual average $PM_{2.5}$ concentration entered into force. Until and including 2019, the limit value of 25 μg·m^{-3} applied.

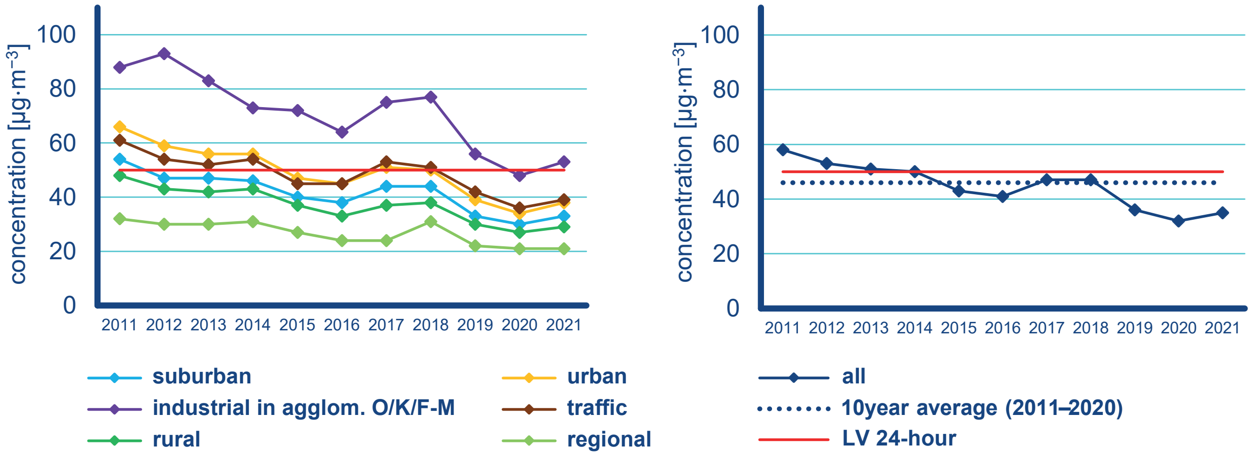

Fig. IV.1.17 The 36th highest 24-hour PM_{10} concentrations at particular types of stations, 2011–2021

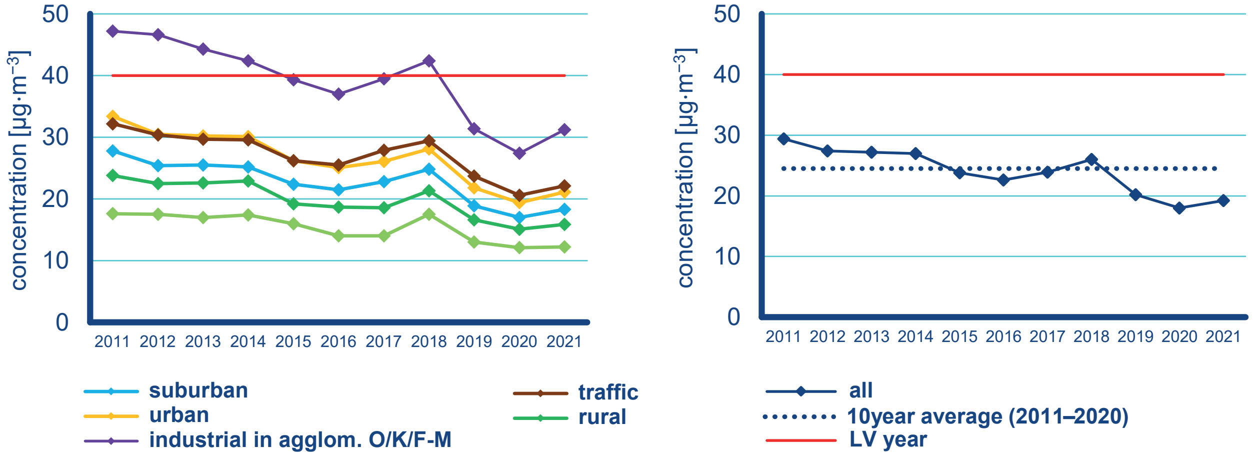

Fig. IV.1.18 Annual average PM_{10} concentrations at particular types of stations, 2011–2021

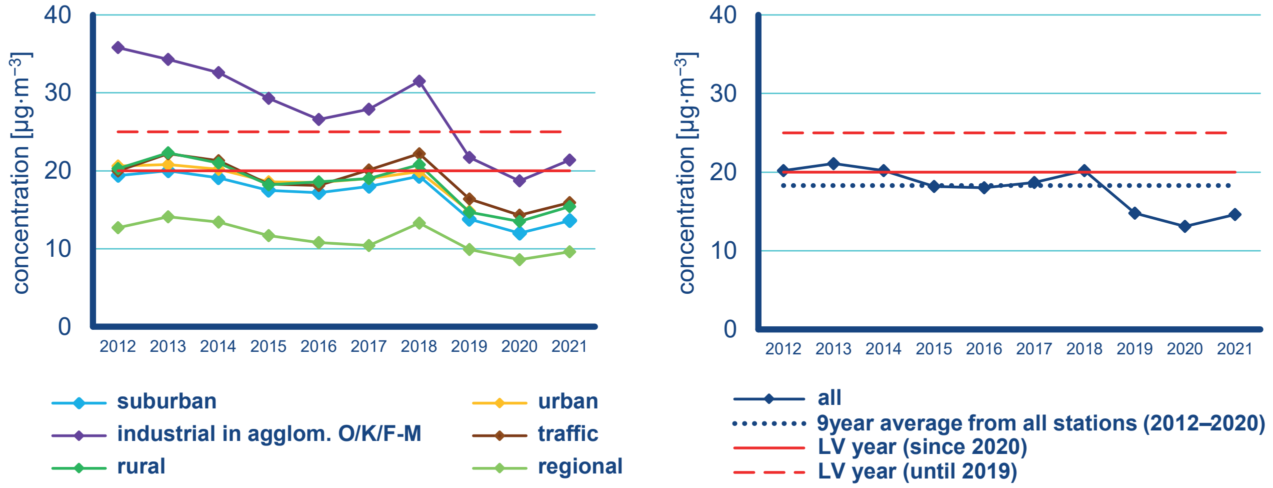

Fig. IV.1.19 Annual average $PM_{2.5}$ concentrations at particular types of stations, 2012–2021

ase again in 2019 and 2020, with a more pronounced decrease recorded in particular between 2018 and 2019. Concentrations in 2021 were at the second lowest level in this period after 2020, which was extremely good in terms of air quality. Compared to the ten-year average of concentrations from all stations (46 μg·m^{-3}), the annual average PM_{10} concentrations in 2021 (35 μg·m^{-3}) decreased by almost 24 %.

Annual average PM_{10} concentrations (on average from all stations with measurements available for the entire evaluated period) ranged from approximately 18.0 to 29.4 μg·m^{-3} in the period 2011–2021 (Fig. IV.1.18). During the evaluated period, the minimum concentrations were recorded in 2020, the maximum in 2011. The trend of annual average concentrations is similar to the trend of 36th highest 24-hour PM_{10} concentrations. Concentrations in 2021 were at the second lowest level for this period after 2020, which was exceptionally good in terms of air quality. Compared to the ten-year average of concentrations from all stations (24.5 μg·m^{-3} for the period 2011–2020), the annual average concentration of PM_{10} in 2021 (19.2 μg·m^{-3}) decreased by almost 22 %.

The longer-term trend of annual average concentrations of $PM_{2.5}$ can be assessed over the last nine years (in view of data availability and continuous time series at observing stations). Annual average concentrations of $PM_{2.5}$ ranged from approx. 13.1 to 20.0 μg·m^{-3} in the period 2012–2021 (Fig. IV.1.19). During the evaluated period, the minimum concentrations were recorded in 2020, the maximum in 2012 and 2018. Compared to the nine-year average of concentrations from all stations (18.3 μg·m^{-3} for the period 2012–2020), the annual average concentration of $PM_{2.5}$ decreased in 2020 (14.6 μg·m^{-3}) by 20 %.

The continuing decrease in concentrations of suspended PM_{10} and $PM_{2.5}$ particulates can be attributed to a combination of factors, both to good meteorological and dispersion conditions in some months of the year and to continued emission reductions due to measures already implemented to improve air quality (replacement of boilers, the ongoing renewal of the vehicle fleet and measures implemented at large sources). The effect of measures associated with states of emergency declared on the territory of the CR in connection with the occurrence of the SARS-CoV-2 coronavirus in relation to changes in the concentration of suspended particulates is inconclusive.

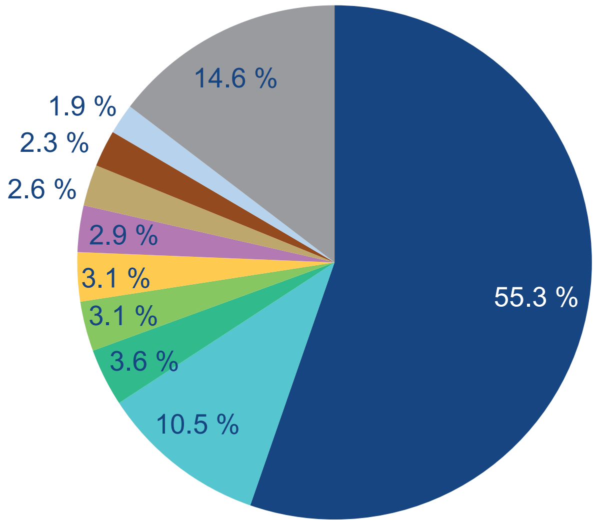

Fig. IV.1.20 Share of NFR sectors in total PM_{10} emissions, 2020

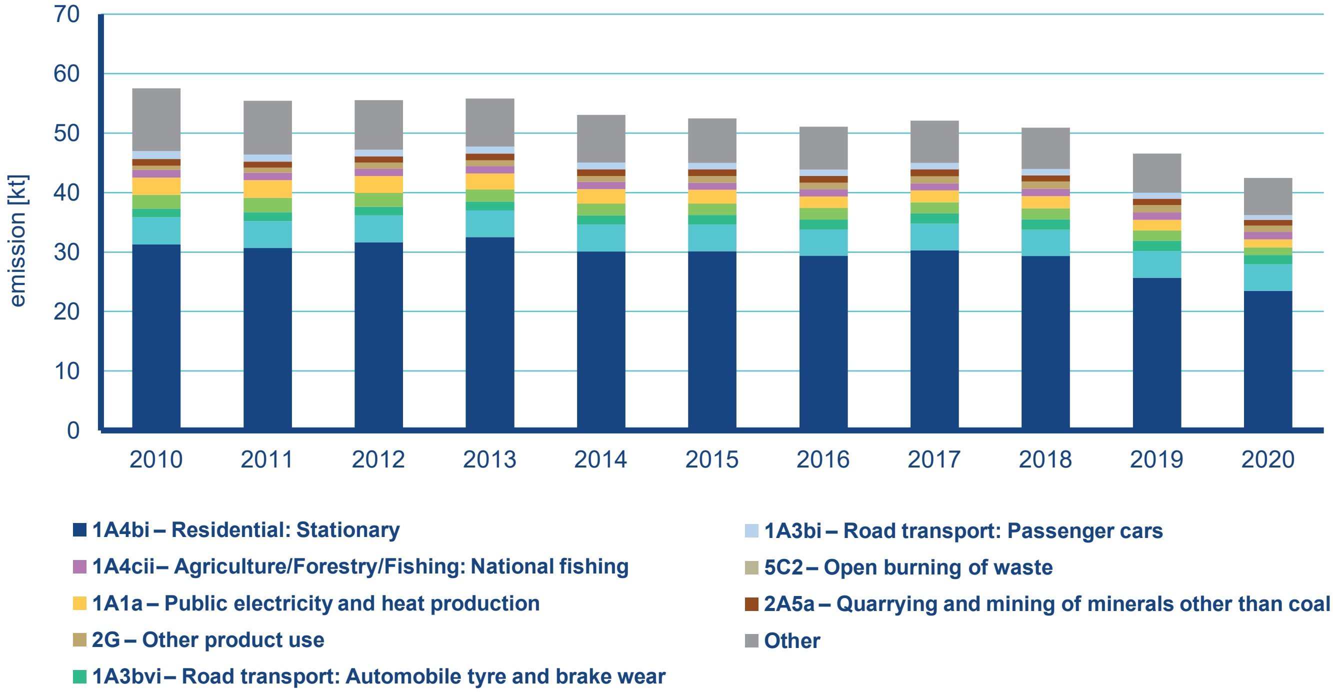

Fig. IV.1.21 Total PM_{10} emissions, 2010–2020

IV.1.3 Emissions of PM_{10} and $PM_{2.5}$

Aerosols originating from fuel combustion and other industrial activities can exist in the form of solid, liquid or mixed suspended matter. Taken together, these aerosols are termed Total Suspended Particulates (TSP) (solid pollutants (SP) in the Czech legislation). TSP emissions have varying size and chemical composition resulting from the characteristics of the source and the mode of formation. They can contain heavy metals and act as carriers for VOCs and PAHs. The PM_{10} and $PM_{2.5}$ size fractions are most frequently distinguished in emission inventories in relation to pollution limit levels.

Emission inventories of PM_{10} and $PM_{2.5}$ prepared according to current regulations include only the primary emissions of these substances. However, a considerable contribution to airborne concentrations of PM_{10} and $PM_{2.5}$ comes from secondary suspended particulates formed directly in the air from gaseous precursors through physical-chemical reactions. The fraction of secondary suspended inorganic particulates in total $PM_{2.5}$ concentrations in urban environments can vary between 20 and 40 % (Vlček, Corbet 2011). According to the model estimate, the contribution of secondary suspended organic particulates of biogenic origin under European conditions can equal 2–4 μg·m^{-3} of $PM_{2.5}$ (Fuzzi et al. 2015).

Compared to emissions of other pollutants, particulate matter emissions in the air originate from a great many significant source types. In addition to sources from which these substances are emitted through controlled chimneys or stacks (industrial production, household heating, transport exhaust emissions), significant amounts of TSP emissions originate from fugitive sources (quarries, dumping of dusty materials, manipulations involving dusty materials, etc.). Relevant sources include also emissions from abrasion of tyres, brake linings and abrasion of roads calculated from traffic intensity. The air quality is also affected by the resuspension of particles, which is not included in the standard emission inventories.

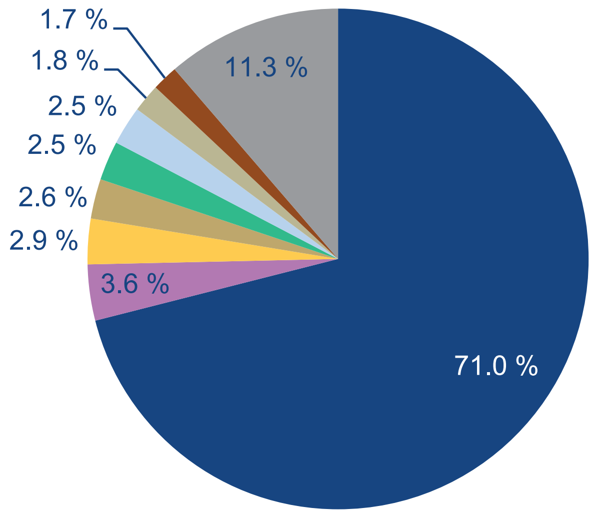

Fig. IV.1.22 Share of NFR sectors in total $PM_{2.5}$ emissions, 2020

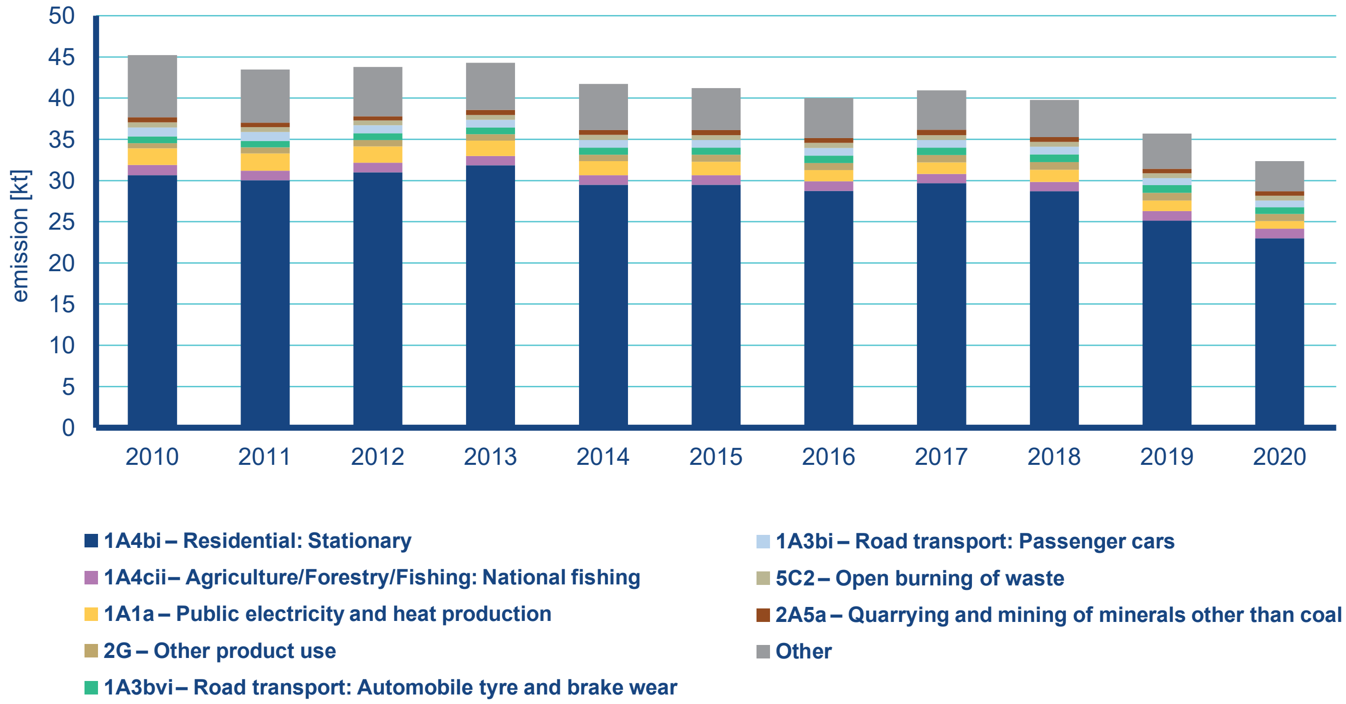

Fig. IV.1.23 Total $PM_{2.5}$ emissions, 2010–2020

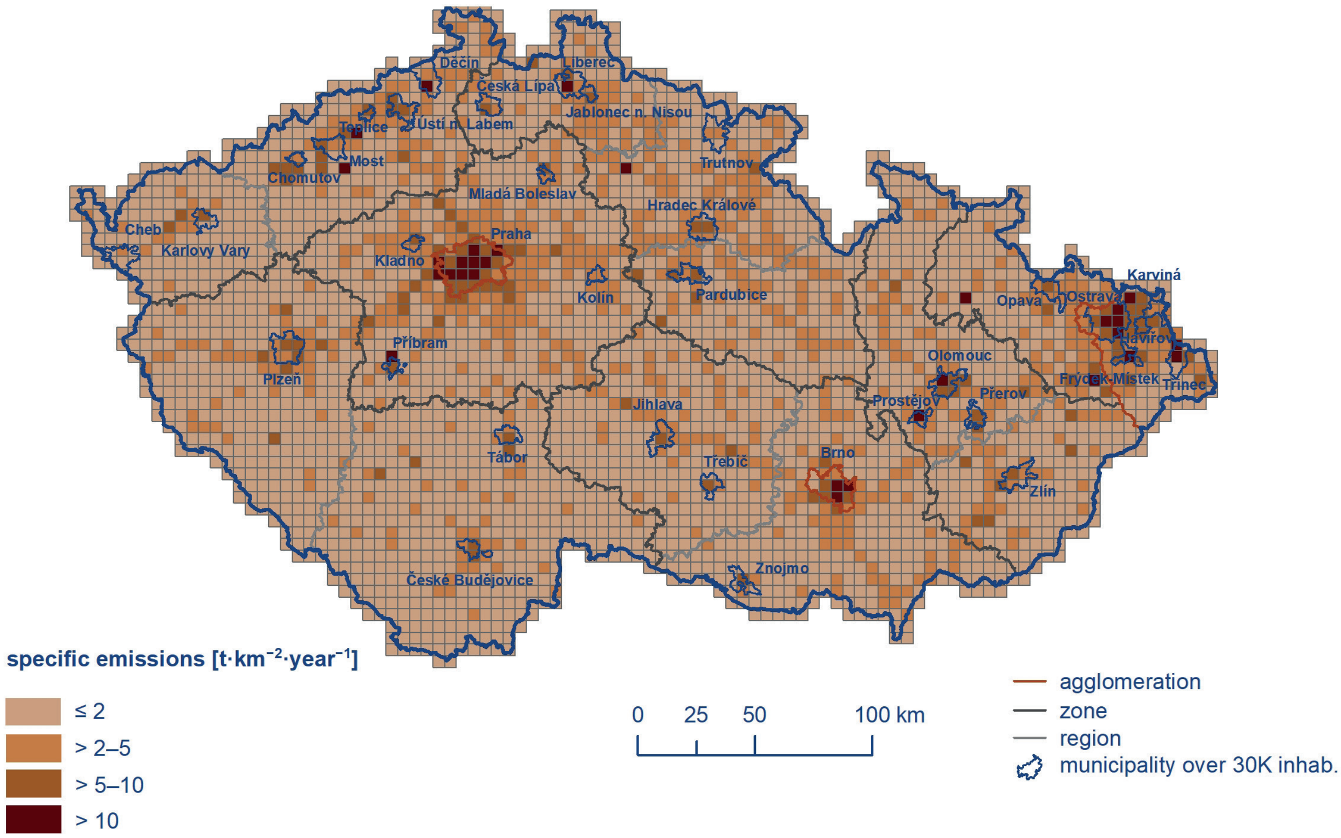

Fig. IV.1.24 Total PM_{10} emissions in 5×5 km spatial resolution squares, 2020

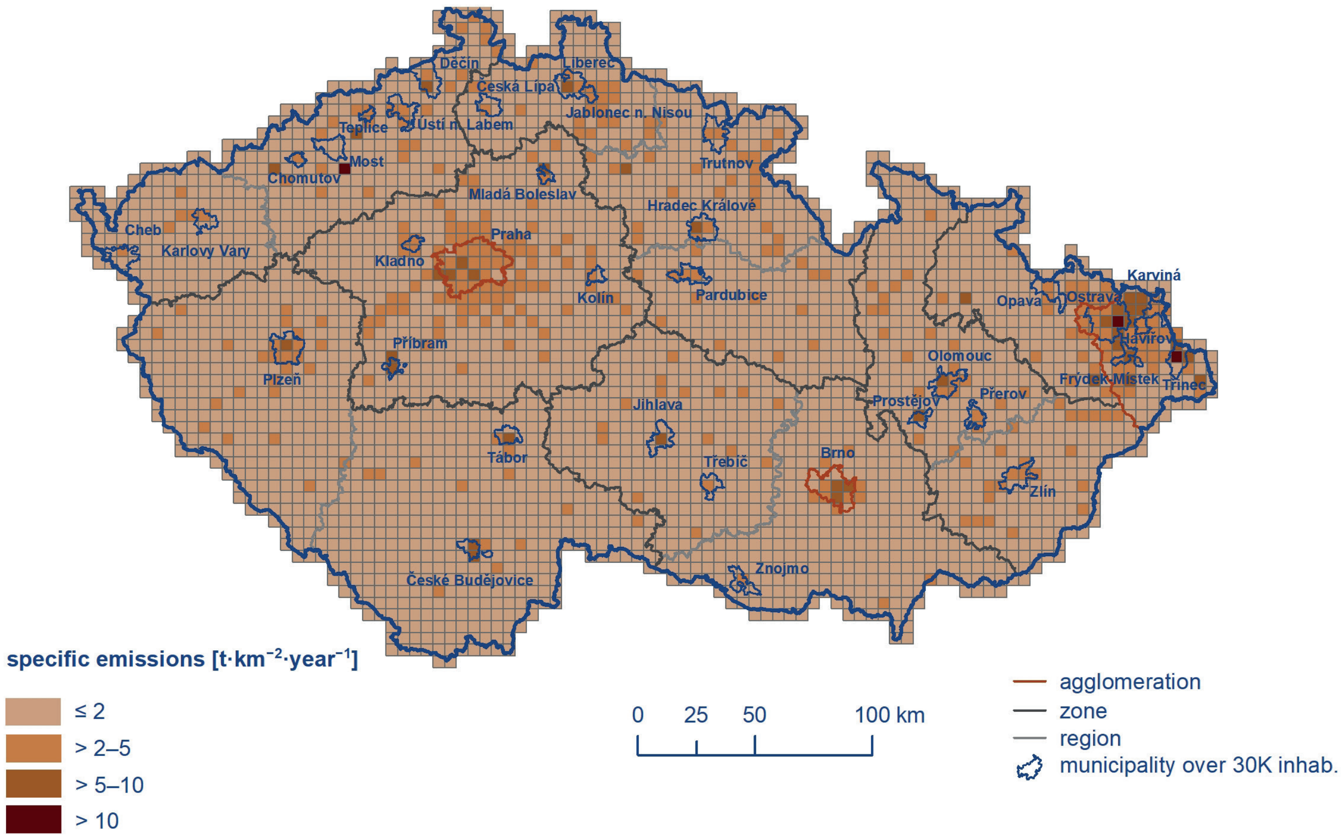

Fig. IV.1.25 Total $PM_{2.5}$ emissions in 5×5 km spatial resolution squares, 2020

The main sources of particulate matter emissions in 2020 (Fig. IV.1.20 and Fig. IV.1.22) included sector 1A4bi — Residential: Heating, water heating, cooking, which contributed 55.3 % of PM_{10} substances and 71 % of $PM_{2.5}$ substances to air pollution on a country-wide scale. Further important sources of PM_{10} emissions included sector 3Dc — Farm-level agricultural operations including storage, handling and transport of agricultural products, with emissions formed during tillage of the soil, harvesting and cleaning of agricultural crops. This sector represented 10.5 % of PM_{10} emissions. A substantial risk to human health is caused by particulates coming from transport, especially from fuel combustion in diesel engines that produce particles with sizes up to hundreds of nanometres (Vojtíšek 2010). Mobile sources (CHMI 2022d) contributed 11.7 % to PM_{10} emissions and 11.8 % to $PM_{2.5}$ emissions in 2020.

Solid fuel consumption in households, affecting significantly emission levels, can be characterized by a growing trend in the period 2010–2020, possibly related to the economic situation. Nevertheless, the resulting effect has been compensated by natural renewal of the vehicle fleet, a decrease in agricultural production, and in particular the use of the best available techniques for reducing TSP emissions (fabric filters) in the energy and industry sectors. Total PM_{10} and $PM_{2.5}$ emissions in nearly the entire period 2010–2020 therefore show a declining trend (Fig. IV.1.21 and Fig. IV.1.23).

In individual regions of the CR, the contribution by sectors varies depending on the composition of sources in a given area. Since the main source of PM_{10} and $PM_{2.5}$ emissions is from local heating, the production of these substances is also distributed throughout the territory of the CR along with residential buildings. In the territory of the CR, areas with higher emissions correspond to sites where lignite mining takes place and important energy sources using solid fossil fuels or large industrial complexes are located (the Ústí nad Labem and Moravian-Silesia regions). The fraction of suspended particle emissions from transport is greater primarily in large cities (Fig. IV.1.24 and Fig. IV.1.25).